Dairy replacement rearing – A comparison of an integrated management system using fodder beet and traditional rearing systems.

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Ella Cvitanovich

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Abstract

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Heifer rearing systems in New Zealand were compared in a theoretical study on weight and financial costs. The systems compared were restricted fodder beet, *ad libitum* fodder beet, contract grazing and on-platform pasture grazing. The aim was to identify the most cost effective rearing system to ensure heifers are grown to achieve or exceed target live weights at 15 and 22 months. Potential live weight gains were calculated through metabolisable energy in feed and daily animal intakes using reference feed standards. The pre-mating average daily weight gains were 0.59 kgLWT/day, 0.53 kgLWT/day and 0.49 kgLWT/day for the *ad libitum* fodder beet, restricted fodder beet and pasture grazing respectively. None of these diets meet mating live weight targets, however *ad lib* fodder beet was the closest at 1.8%. The weight gains between mating and calving on the *ad libitum* fodder beet diet and restricted fodder beet diet were 0.59 kgLWT/day and 0.53 kgLWT/day respectively, higher than 0.49 kgLWT/day seen in the pasture grazing systems. The *ad libitum* fodder beet diet live weights were undesired at 29.4% above target, however the other systems meet target weights. The most expensive rearing system was contract grazing at $2.85/kgLWT gained. This was followed by on-platform pasture grazing at $2.57/kgLWT gain. Fodder beet has the lowest cost of gain at $2.27/kgLWT gain. Cost analysis showed that live weight gain, not cost of crop, is the key driver of cost effective rearing systems. This research demonstrates that under careful management and feed restrictions fodder beet is a suitable and cost effective way to rear heifers in the New Zealand dairy industry.

Keywords: Heifer, Holstein-Friesian, Rearing, Cost of gain, New Zealand, Fodder Beet, *ad-libitum,* restricted, Pasture, Contract grazing, Live weight, Mating, Calving.

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Chapter 1

Introduction

The reproductive performance of the New Zealand dairy herd has decreased (Harris, 2006), however with conception rates at around 60%, it is considered higher than most other countries. One of the reasons for decreasing fertility is the result of negative genetic correlations among fertility and milk production. Due to this, a greater focus is being put on fertility in the New Zealand diary industry.

Heifer rearing is one of the key barriers to increasing the reproductive performance of any dairy herd. In New Zealand it is very common to graze heifers on-platform or run-off block, or through a contract grazing company, on pasture. The grazing period begin after weaning and continues through till 22 months, leading up to their first calving and lactation period. In New Zealand heifers are traditionally mated at 15 months through natural insemination.

In a recent study of the current dairy industry, 74% of animals were below target at 22 months, and 61% below target at mating (McNaughton & Lopdell, 2012). This is a large barrier for running an efficient and profitable dairy farm, as there can be many long lasting implications from not meeting targets. These include decreased fertility, decreased body weight post calving and decreased milk yield (Archbold, Shalloo, Kennedy, Pierce, & Buckley, 2012) (Vander Waaij, Galesloot, & Garrick, 1997) (Thomas & Mickan, 1987). Live weight targets for heifers are well established and are based off the expected mature live weight of animal. These targets are 30%, 60% and 90% at six months, 15 months (mating) and 22 months (pre-calving). This gives farmers a benchmark to monitor their performance, and is important for the sustainability and financial performance of farms.

This study analysed the ability and cost of rearing of four different systems to sustain target live weight gains over the rearing period. The systems compared were restricted fodder beet, ad lib*itum* fodder beet, contract grazing and on-platform pasture grazing. Live weight targets were based on the DairyNZ target live weights for Holstein-Friesian X Jersey heifer with a mature live weight of 450kg. However, the models produced can be altered easily to any breed if the estimated mature live weight is available.

An efficient heifer rearing system is crucial as it determines the future income and sustainability of the dairy enterprise. The aim of this study was to identify the most cost effective rearing system to ensure heifers are grown to achieve or exceed target live weights at mating and pre-calving. Potential live weight gains were calculated through metabolisable energy in feed and daily animal intakes, using reference feed standards.

Chapter 2

Literature Review

2.1 Introduction

The purpose of this literature review is to evaluate dairy heifer rearing systems in New Zealand, particularly in regard to the economic benefit and live weight gain efficiency of the systems. Other benefits and disadvantages of the systems will also be discussed, such as environmental concerns and management factors. The literature reviews will identify areas within the topic that lack knowledge and areas of potential research.

The majority of literature came from journals or conference proceedings, which have been peer-reviewed, making the findings of the trials reliable. Many of the results discussed came from within New Zealand; therefore it is directly relevant to New Zealand farming systems. However, the majority of data comes from the southern regions of New Zealand, as this is the main region for winter cropping research in New Zealand.

2.2 Replacement Rearing

Heifers are an important aspect of New Zealand dairy farming. With an average replacement rate of 22%, heifers coming into the herd can have a large influence on herd productivity. Reaching ideal target live weights is the key factor to ensuring fertility and milk solids (MS) production is maximised. If heifers do not reach target live weights their peak MS production level will be decreased, lactation length shortened and time of potential mating delayed (Thomas & Mickan, 1987).

The reproductive performance of the national dairy herd has decreased (Harris, 2006), and poor calf management and heifer rearing is potentially the limiting factor to correcting this issue. Reaching live weight targets at mating age (13 to 15 months) is crucial for heifers, to ensure they have undergone puberty and begun cycling. Heifers that have undergone their third oestrous had a 78% conception rate, compared with 57% in heifers on their first oestrous cycle (Byerley, Staigmiller, Berardinelli, & Short, 1987). Ensuring heifers meet target live weights will increase the efficiency in the dairy industry as breeding through artificial insemination (AI) and natural mating can be costly and time-consuming.

The key driver of productivity on any dairy farm is MS production. Optimising the kgMS produced per cow will increase profit the profit margin, as the majority of on-farm costs do not change with production levels. Published data concludes that immature heifer live weights will limit a cow's production potential. A 1kg increase in immature live weight will result in a lactation yield increase of

6.7 litres in the first season, however, responses may be lower in subsequent seasons (Vander Waaij et al., 1997). Conversely to this Thomas & Mickan (1987) reported that provided heifers were heavy enough to conceive, their milk production at first lactation will not be significantly affected.

2.2.1 Target Live weights

Table 2.1 Target live weights of dairy replacement heifers as a % of mature live weight (DairyNZ, 2015a)

Age in Months	% Of Mature Live weight
3	20%
6	30%
9	40%
15 (mating)	60%
22 (pre-calving)	90%

Live weight targets for heifers in New Zealand are well established and related to mature live weights. Using target live weights between weaning and puberty is a good way to measure progress and ability to reach the target before first calving. These live weight targets are expressed as a percentage at each milestone, as shown in table 2.1. Reaching the 60% of mature live weight at 15 months is very important as this the time of traditional mating in New Zealand.

A study by McNaughton & Lopdell (2012) extracted data for 211,542 animals from the Livestock Improvement Corporation (LIC) database. After interpretation of this data, they came to the conclusion that 61% and 74% of animals were below the target live weight for 15 and 22 months of age respectively. The highest range portion of underweight animals was 11-20% below target, with 26% and 35% of animals below target at 15 and 22 months respectively. This data set is reliable as it covers a large herd size and the animals are NZ based (McNaughton & Lopdell, 2012). There was only one period, between 12 and 15 months, where average daily gains exceeded their targets. This period coincided with early spring when pasture is abundant and high in quality; this effect will be discussed in depth further into the literature review. The excess live weight gain rates did not compensate for months spent below target daily gain rates.

The most common breed of cattle found on NZ dairy farms is a Holstein-Friesian and Jersey cross (HFxJ); this breed is expected to have a mature live weight of 450kg. The target live weight for this breed at mating would be 270kg (table 2.2), anything below this will compromise the chances of conception at first mating.

Table 2.2 Target live weight values of HFxJ heifers (DairyNZ, 2015a)

Age in months	Target live weight (kg) for HFxJ
3 (20%)	90kg
6 (30%)	135kg
9 (40%)	180kg
15 (60%)	270kg
22 (90%)	405kg

The New Zealand dairy industry aims to achieve a 78% in-calf rate after 6 weeks of mating. The current average value in New Zealand is 65%, which heifer rearing holds some responsibility for. This figure is important as getting more cows in-calf during early mating will shorten the calving period, increase the days in early lactation, increased amount of AI calves and result in less empty cows. To increase the six-week in-calf rate cows must be cycling at the beginning of mating, this is directly related to live weight, emphasising the importance of heifer rearing. The end of calving and final measure is an empty rate. The average empty rate for New Zealand in 2011 was 13%. This is based on the entire herd, not young stock only. Live weight at calving is also a significant factor in successful dairy farmers

An Irish study by Archbold *et al.* (2012) assessed the influence of age, body weight (BW) and body condition score (BCS) of Holstein-Friesian heifers at mating start date (MSD). BW and BCS showed positive relationships with calving date ($P<0.05$), subsequent cow BW ($P<0.001$) and potential lactation yield ($P<0.001$). The study showed that as BW at MSD increased the milk solid yield over the following three lactations also increased (Table 2.3).

Table 2.3 The effect of live weight at MSD on milk solid production over three lactations (bold figures within the same row are significantly different) (Archbold et al. 2012).

Milk Solids (Kg)	<290kg BW	291-316kg BW	317-342kg BW	>343kg BW
1st Lactation	383	**394**	404	417
2nd Lactation	448	**462**	**467**	478
3rd Lactation	474	**487**	**469**	503

However, due to lower reproductive efficiency in heifers grown >343kg at MSD the optimum weight of heifers at MSD was 330kg, or 60% of mature live weight. This supports the New Zealand industry standard target live weights (Table 2.1, 2.2). This study also showed that longevity was also highest in the 317-342kg group of heifers over the three lactations. Improved longevity of the herd will reduce the replacement rate, which will have economic benefits for the farm.

2.2.2 Reaching target live weights

Overall New Zealand heifers are not reaching target live weights as young stock. A heifer's ability to reach target live weights is dependent on many things; calving to weaning care, feed quality and dry matter intake, drenching and BCS. These factors can become obstacles to achieving target live weights if not managed properly. The growth and development of stock between calving and weaning is a crucial part of setting heifers up to meet target live weights. The first step is ensures calves get 2 litres of fresh colostrum during the first 6 hours of life (Quigley, Hammer, Russel, & Polo, 2007), this is best achieved by collecting calves twice daily. The role of colostrum is for the calf to obtain protective antibodies, to create a passive immune system, as the calves active immune system does not begin to work until 14 days of age (Quigley et al., 2007). By obtaining antibodies, as well as been housed in warm, dry conditions, the calves will have the best start to life and set themselves up to achieve target live weights.

Another pre-weaning factor is rumen development. Calves digest milk in their fourth stomach, the abomasum, through the oesophageal groove. Poor developments of the rumen before weaning can cause a growth halt and affect growth rates post-weaning. After weaning the stock will be able to break down grass in the rumen by bacteria fermentation. The digestion of milk alone does not provide the end products needed to develop the rumen papillae, which increase rumen surface area, thus increasing the efficiency of nutrient absorption. Solid feeds, unlike liquids, are directed to the reticulorumen for digestion. Solid feeds stimulate rumen microbes, which create microbial end products, such as volatile fatty acids, which stimulate epithelial development. Feeds differ in their ability to stimulate rumen development, which is a result of their chemical composition (Heinrichs, Lesmeister, & Garnsworthy, 2005). Concentrates, or grain feeds, which contain high levels of casein, starch and cellulose, have an increased rate of rumen development compared to forage. Research has identified butyrate and propionate as being the most readily absorbed volatile fatty acids by rumen epithelium (Baldwin & McLeod, 2000), which has lead industry professionals to agree that a diet of milk and grain should be recommended for improved rumen development and the best start to post-weaning growth.

In New Zealand dairy systems, calves are often monitored very closely to ensure adequate live weight and health at weaning. However, post-weaning results are not as consistent. Table 2.4 gives an indication of DM intake requirements for the stock to meet live weight targets, based on an 11.0 MJME diet. However, some of these values may be unobtainable as cows can only consume a maximum of 4% of their bodyweight. A study by Hoffman (2008) showed that heifers between 163-

499kg LW consumed between 4.6 and 10.06 kgDM/day respectively, which are similar amounts to those displayed in table 2.4. When the DM intakes were expressed as a percentage of LW the values fell between 2.01-2.89%, showing that they were achievable. Although this study was conducted for 24 months, it had a very small sample size of 8 cows per breed, which will limit the validity of the results (Hoffman, Weigel, & Wernberg, 2008).

Table 2.4 Daily DM intakes for HFxJ heifers (DairyNZ, 2015a)

	Live weight gain (kg/day)	**3 months (20%)**	**6 months (30%)**	**9 months (40%)**	**15 months (60%)**	**18 months (73%)**	**22 months (90%)**
HFxJ	**0.55**	3.2kg DM/day	4.1 kg DM/day	5.0 kg DM/day	6.6 kg DM/day	7.6 kg DM/day	9.9 kg DM/day

Table 2.5 Dry Matter Requirements for Grazing Heifers (DairyNZ, 2015b)

Current live weight (kg)	Dry Matter requirements for daily live weight gain (kg/day)			
	0.2	**0.4**	**0.8**	**1.0**
150	2.9	3.5	5.2	6.0
250	4.2	5.1	6.1	7.0
350	5.4	6.5	7.6	8.7

2.3 Pasture Grazing

2.3.1 Metabolisable energy supply

The metabolisable energy (ME) of a feed is a very important factor in animal growth and development. It is a concept used to quantify the nutritional value of feedstuffs provided to the animal. ME values are dependent upon performance and condition of the animal, as well as the qualities of different components in the feed. It is often an *in-vitro* estimate, which predicts the amount of digestible energy (DE) from a feed material. It is expressed in mega joules per kilogram of feed (MJ/kg DM). ME measurements have become a crucial tool for farmers, particularly in the dairy industry, for comparing the nutritive values of feed materials. It is the preferred indicator of a feeds ability to support production as it gives more information than dry matter content.

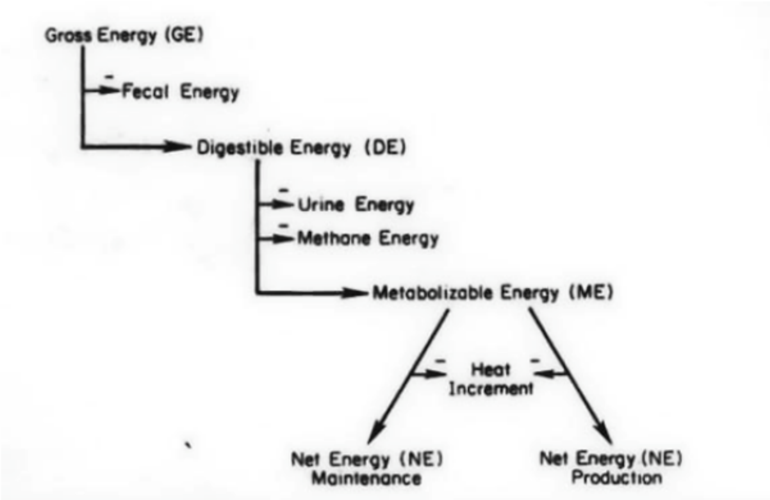

Figure 1 Energy Pathways in Ruminants (Huston & Pinchak, 1991)

Gross energy (GE) level of feed does not vary largely between feeds, and values usually reflect the carbohydrate content. Most feedstuffs will fall within the 17-18 MJGE/kgDM ranges. The ME is the energy available to the animal after all heat and chemical losses have taken place, as illustrated in figure 1. Faecal and urine losses are chemical losses, where methane is a heat loss. This means that the energy has changed form and there is inefficiency in the system.

In New Zealand dairy systems the main form of energy is pasture and other forage crops. In high-forage systems like these, cows will ruminate or regurgitate ingested forage. This allows them to reduce particle size, improve digestibility, and therefore increase percentage of energy obtained from metabolisable energy. Once the bolus (chewed food) enters the reticulorumen, it is exposed to a population of microbes, which begin to ferment and digest the plant cell, breaking it down these components into carbohydrates and sugars (AFRC, 1993). The microbes in the rumen use the carbohydrates, along with amino acids, to grow. The microbes ferment the sugars to produce volatile fatty acids (acetate (65%), propionate (20%), and butyrate (14%)) (CSIRO, 2007) along with methane and carbon dioxide. The VFAs are absorbed across the rumen wall, after this the VFAs are converted to glucose. This is a very slow system, which requires a lot of chewing and rumination; this encourages salivary flow and produces a stable pH environment in the rumen (around 6.0). Forage diets are typically a structural carbohydrate based diet, with fat making up less than 10%. In New Zealand pastures are highly managed, this means that the shift in diet component between seasons is significant.

New Zealand pastures vary a lot throughout the country dependent on climate and irrigation restrictions. Overall pasture, most commonly a ryegrass and white clover mix, supplies 10-11 MJME/kgDM to the animal grassing. Dry matter production across New Zealand is also very high, with a range of 11-16 tDM/ha produced annually, dependent on location.

2.3.2 Protein Content

Table 2.6 Average pasture quality parameters for New Zealand seasons (DairyNZ, 2011b)

	Dry matter (DM) (%)	ME (MJ ME/kgDM)	Crude protein (CP) (% of DM)
Spring Pasture	12-15	11.5-12.5	20-30
Summer Pasture	15-20	9.5-10.5	14-22
Autumn/Winter Pasture	13-18	11.0-11.5	15-20

Proteins are the building blocks for meat and muscle in any animals; it is because of this that young animals offered low-quality feeds have decreased live weight gains and show poor condition. Dairy cows have little ability to store protein, meaning they need a constant supply from their diet. When talking about crude protein (CP), a measurement of nitrogen (N) in the feed (CP = 6.25 x N) is being discussed. CP measures the nitrogen content of feedstuffs, including both true and non-true protein nitrogen. All protein contains nitrogen, which is used by the microorganisms in the rumen to increase feed digestibility. Approximately 90% of the protein in a pasture is available for degradation in the rumen at various rates. Microbes in the rumen break plant proteins down to ammonia and amino acids, this is then synthesised into microbial protein or absorbed into the blood stream as ammonia (Lambert & Litherland, 2000). The microbial protein and slowly degradable protein moves down the digestive tract until it is degraded to amino acids in the small intestines and absorbed (Waghorn & Barry, 1987). New Zealand pastures generally have a high protein content, especially during summer months, typically 50 to 100% more than required by the cow (DairyNZ, 2011b). Dairy cows in New Zealand will generally meet requirements unless more than 50% of their diet is coming from a low protein supplement, such as maize silage (7.5% CP), which is increasingly popular because of its low cost. The protein requirements for dairy cows at various stages of lactation are exhibited in table 2.5, which shows the most demanding period is early lactation when the cow requires 18% CP. In a New Zealand, spring calving system early lactation will occur in late August-early September. Table 2.4 shows us that the average crude protein of spring pasture is 20-30%, which supports information from DairyNZ that this is not a major issue in a pasture-based system. The CP of New Zealand pastures at the time of weaning in table 2.5 show that young stock will have an adequate supply to continue growth as well as proper rumen development and function. Research has shown that metabolisable energy is a bigger restricting factor than protein content in the pasture based system.

Table 2.7 Crude protein requirements for dairy cows

	Crude Protein Required
Early Lactation	18%
Mid-lactation	16%
Late lactation	14%
Dry period	10-12%

2.3.3 Seasonal Differences

Pasture quality in New Zealand is manipulated heavily by seasons, which influences the feed offered to dairy cows. The farming system has been customised over time so that periods of high animal demands are paired with periods of high-quality pasture. However, in some situations, the supplementary feed may need to be supplied as well as pasture. The results from a study by Dally and Geddes (2012) showed that estimated annual pasture DM production rates varied from 7.6t DM/ha to 14.3t DM/ha through the various parts of the South Island. As well as variation between regions there was also large variation between seasons. All regions showed reasonably predictable growth rates through winter and early spring, however, late spring and summer growth rates were more variable between years, and the study was conducted for five years. Growth rates vary throughout the year due to weather changes, particularly temperature and rainfall as these are crucial components of plant growth (Dalley & Geddes, 2012). As described in table 2.7 there is evidence across the three farms that pasture growth is at its lowest during the winter months (June, July, August). This is a large influence for dairy farmers to graze replacement heifers off platform to ensure their nutritional needs are meet, another option is growing winter crops, which can handle cold weather and meet animal requirements, and example of this is fodder beet.

MJ ME/kg DM value of pasture refers to the amount of energy able to be used by the stock per kilogram of dry matter consumed; this is a parameter, which defines feed quality. Published values for MJME/kg DM in New Zealand are 10.7, 10.7, 11.2 and 11 MJME/kgDM for summer, autumn, winter and spring respectively (Webby & Bywater, 2007), these values are similar to published values shown in Table 2.8. The low temperatures and high rainfall during winter results in a pasture with a high digestible energy, this is the main driver of pasture quality as mentioned earlier. These values can also be justified by high stocking rates, as discussed earlier this will improve the pasture quality and digestibility which is the driver of ME. By having a high grazing pressure the stock will not be selective and graze all components of the sward to a low level. This ensures there is minimal plant material left behind which will turn to dead material before the area is grazed again.

Table 2.8 Growth rates of three Southland and Otago dairy farms (Dalley & Geddes, 2012)

	Growth rate (kgDM/ha)		
Month	Woodlands	Northern Southland	South Otago
June	7	2	10
July	4	1	3
August	9	9	12
September	21	24	28
October	42	43	46
November	64	45	50
December	51	22	45
January	45	26	48
February	49	25	41
March	45	24	41
April	34	17	31
May	14	10	23

Table 2.9 Pasture quality parameters from the Tararua area (* highly significant difference) (Litherland et al, 2002)**

	ME (MJME/kgDM)	CP%
Summer	10.0	18.1
Autumn	9.2	21.9
Winter	10.6	23.2
Spring	10.3	22.6
Significance	***	***

2.3.4 Grass Price

It is very common for grass to be sold at a standing price; this price is also transferred to the cost of growing grass. The grass price in New Zealand is highly variable due to the changing climate and different ME values, due to the region. Current and historical prices show us that the cost of grass can range between 19-33c/kgDM (DairyNZ, 2006; FAR, 2006; Pioneer, 2015)

2.4 Fodder beet

Over the last ten years, the use of Fodder beet in New Zealand has changed greatly, with use in winter grazing systems. Fodder beet is a high energy feed, it has an average of 12 MJME/kgDM (S. Gibbs & B. Saldias, 2014; Givens & Brunnen, 1987). Initially, fodder beet became an alternative feed for farmers struggling with long-term winter brassicas. However, fodder beet is now used widely in New Zealand across all livestock classes. Fodder beet has an average annual yield of 15-40 tDM/ha, with average establishment costs of $1,800-2,300/ha. Despite fodder beet having higher production costs, it is becoming a preference for dairy farmers. This is due to the high yield and energy value, as well as a high tolerance to insects and diseases. As use has increased, there has been more research and a greater understanding into issues with the crop and best practice grazing regimes. These studies have been completed in New Zealand and include work from Gibbs and Saldias (2014) and Edwards *et al.* (2014). The key to success when grazing fodder better is to follow best practice guidelines and not take shortcuts. Fodder beet can provide a flexible, high-quality feed option, which can deliver high yields in autumn, winter and early spring. The utilisation by animals is also high by all livestock classes. Fodder beet in the dairy system is important for extending the lactation period and transitioning to winter-feed. It also used as a finishing system for heifers when live weight gains are very important (Archbold et al., 2012; McNaughton & Lopdell, 2012; Thomas & Mickan, 1987; Vander Waaij et al., 1997; Walker, Martin, & Buttrey, 2015). Research by Gibbs and Saldias (2014) showed that fodder beet could sustain high live weight gains, with rising 1 year-old cattle achieving daily live weight gains between 0.81 and 0.98kg/day.

Animal health caution is very important when feeding high energy feeds, as there is a risk of rumen acidosis, which occurs almost exclusively in the transition period. Acidosis was found to occur when the rumen pH level falls below 5.5, the normal pH level in the rumen is 6.5-7.0. Low pH has two effects. Firstly, the rumen stops moving and becomes atonic. This suppresses appetite, which then limits animal production. Secondly, the acidic environment changes the rumen flora; the acid producing bacteria continue to produce acids, which worsens the acidosis. Increased acids are absorbed through the rumen wall, which causes metabolic acidosis. This can lead to severe cases of shock and stock death (Garrett et al., 1999). Research by Gibbs and Saldias (2014) using rumen fistulae cows in wintering systems, showed there were no significant differences between *ad libitum* and restricted grazing on fodder beet (after appropriate transitioning onto fodder beet). This was explained by a change in feeding pattern, moving from rapid consumption to a slower intake pattern over the whole day (J. Gibbs & B. Saldias, 2014). Transitioning is a very important part of feeding fodder beet in the diet, even if the animal is familiar with the crop. Supplement choice plays a very important role in this process, as it needs to be palatable, easy to access and help the animal eat its protein requirements, silage and grass are commonly used as supplements. Heifers have a lower risk of acidosis during the transition phase than more mature animals. This is because they tend to eat the feed slower, through physical access of the beet, which extends the transition periods.

2.5 Contract Grazing

Contract grazing is a popular form of rearing heifers across New Zealand. Heifers begin arriving from early November, at around 4 months of age but the majority arrive in December at 5 months. Stock stay on the grazier's farm/farms till around 22 months of age when they are returned for their first calving. There are many established contract-grazing companies throughout the country; many of these are branches of veterinary clinics. This is a huge advantage for farmers as they can be confident that their stock is getting all animal health treatments as required. Often these costs are set at the beginning of the grazing period and cover vet visits, lab fees, and animal health interventions such as antibiotics. The VetCare grazing group in Whanganui, New Zealand have set this price at $18/heifer (McGillivary, 2016). Heifer weights are monitored regularly, with roughly seven weighing's as May to May heifers, and with more during winter to ensure target live weight gains are being met. Weaners are usually weighed every six weeks in conjunction with being drenched. All weights are reported to the farmer regularly and are available for direct upload to Minda. Minimum targets are often set by grazing companies (Table 2.9), as well as target live weights from LIC or DairyNZ. Doing this helps them identify graziers who are not performing to standards and take action to remedy it.

Table 2.10 Target weight gain for VetCare grazing (McGillivray, 2016)

Breed	Minimum Weight	Potential Weight
Jersey	0.5	0.6
Friesians	0.6	0.7

Contract grazing has many advantages, major ones being a decrease in on farm labour demand, as there are fewer herds to monitor and feed, which can allow owner-manager farmers to have more time off during the winter. However, the cost of contract grazing can deter some farmers from using this system. Prices vary throughout the country, often dependent on the quality of the grazing as well as milk prices. The drop in milk prices during recent years has resulted in a drop of stock for many grazing companies; Vet Care's numbers have dropped from 9,000 to 7,000 this season. Rising one-year olds graze off platform at a cost of between $5.50-$8/head/week, whereas rising two-year olds cost roughly $10.50-$15.50/head/week (DairyNZ, 2015b; Gibbs, 2016; Hughes, 2016) Many companies also operate an incentive scheme; this encourages graziers to perform well and results in well-grown cows on return to the dairy farm. An example of this is VetCare grazing who have a rate of $1.67/kg. Weaners must be grown to industry standards to enter grazing systems, DairyNZ has set this at 90kg for a kiwi-cross cow, however, most graziers will not accept weaners less than 100kg on the 1st of December.

There are potentially high costs associated with contract grazing, which is incurred during winter when there is limited cash flow on dairy farms. It does allow the farmer more time to achieve other things, often the decision to contract graze is determined by this. It is a personal decision, which is influenced by age and stage in their career.

2.6 Environmental impacts

The public perception of dairy farming and its environmental impacts has resulted in more research as well as rules in regulations. Nitrate leaching is a major area of environmental concerns; it is a natural process, which occurs when nitrate leaves the soil in drainage water. Nitrate (NO_3^-) is soluble and mobile, it is formed from nitrification of ammonium, and it causes no issues in the soil and is readily plant available. However, when nitrate is leached to waterways it can cause eutrophication, this is the rapid increase in algae growth which depletes the water of available oxygen, resulting in the death of other organisms such as fish. Nitrate leaching levels are affected by plant uptake of nitrate and drainage from the soil. Winter is the most likely time for leaching to occur, this is due to increased rainfall and saturate soils, resulting in increased drainage. Crops and pasture are often not growing rapidly at this time, so there is excess nitrate in the soil. Winter feeding practices on dairy farmers are being looked at with scrutiny due to the increased rate of leaching during this period.

Urine patches are responsible for a large proportion of nitrogen losses in grazed systems, which mean a large amount of the whole farm N losses can be found in winter grazing crops. As fodder beet can handle higher grazing pressure than a crop such as kale, there have been concerns about the environmental impact of these increased stocking rates. However due to fodder beets low crude protein content, cows have lower urinary N levels which results in less nitrogen losses (Malcolm et al., 2016). This study by Malcom *et al* (2016) used lysimeters to estimate nitrogen losses; it was based at Lincoln University. The study found that the nitrogen losses under fodder beet were 55-60kgN/ha, lower than kale losses of 75-85kgN/ha. The lower N losses are likely due to less N uptake from the fodder beet, due to its low crude protein content. The urinary N content of stock grazing early kale was 2.0-2.5 g N/L, which was higher than the 1.9-2.3 g N/L of stock grazing fodder beet, however, these results were not significantly different (Edwards et al., 2014). This means that moving away from traditional heifer rearing systems to an integrated fodder beet system could improve the environmental impact of dairy farming.

2.7 Conclusions

- Hearing heifers is a very important aspect of the New Zealand dairy industry, one that is currently not performing as well as it should be, as seen through research and low in calf rates.

- Fodder beet is forage crop emerging onto the market, mainly used in the sheep and beef industry. However, high metabolisable energy levels and sugar levels enable it to maintain high live weight gain levels, giving it huge potential as a heifer-rearing crop.

- Pasture grazing on a run-off block of the platform is the most common scenario for heifer rearing in the current New Zealand system. It is an easily manageable system, in which the farmer has full control over the stock.

- Contract grazing is a good option for those looking for off-farm time as their heifers are left in control of the grazier for the 22 months, which they are away.

2.8 Hypotheses

From the current literature available on rearing heifers in New Zealand and abroad, and the existing work published in heifer rearing on beet, I believe that financially fodder beet will be the best option for rearing heifers in the current dairy system. However, contract grazing and buying grass have non-financial benefits, which will interest farmers. These can include less labour, more time off-farm and simpler management. Fodder beet will have the highest potential for live weight gain due to high metabolisable energy; this will provide an advantage for it, although it may not be desired within this system. I believe fodder beet will be the best option both financially and physically, however it will involve increased labour and management, which will influence farmer's decisions to implement this system.

Chapter 3

Research Methods

3.1 Introduction

As presented in the literature review, there are a number of existing systems for rearing replacement heifers in New Zealand. However, there appears to be a gap in research surrounding the benefits of these systems both economically and from an animal health impact assessment. This study will compare the costs of the system against physical factors such as live weight gain and stocking rate, to see which system is the most cost effective, particularly during the current low payout. The study will compare an integrated fodder beet system, a traditional pasture system and a contract grazing system. The quantitative study requires scenario modelling for each system to determine the profitability. Data will be retrieved from industry professionals, historical data and best practice farms.

3.2 Research Questions

Research surrounding heifer rearing is spread throughout New Zealand, however Canterbury will be the focus for this modelling system. The Canterbury region is the home to 891,843 dairy cows, which accounts for 18.1% of New Zealand's total dairy cows. The average herd size is 806 cows, which is challenged only by Otago with herd sizes of 600. Canterbury also has a high production with an average of 395 kg MS/cow, which is the second highest behind southland with 400 kg MS/cow (DairyNZ, 2014). The Canterbury region provides the most accurate data in terms of fodder beet grazing, as it is a common practice, which has been established for many years.

The research project involves answering the following research questions through modelling about the three rearing systems:

- What are the financial implications of both grazing systems?
- What are the non-economic risks and benefits involved with each system?

3.3 Approach to Research

The most suitable research method to answer questions in this study is quantitative. This is a category of research which includes empirical or statistical research, with the aim of reduce research to numbers (Newman & Benz, 1998). Quantitative research has many advantages. As they are numbers, it is easy for them to be ranked, graphed and compared against previous studies, and provide a baseline for future studies (Creswell, 2013). The quantitative results of this study will compare weight gain and economic costs of various heifer-rearing systems in the hopes to optimise farm profitability.

3.4 Fodder Beet Grazing

3.4.1 Fodder Beet Costs

As fodder beet use increases throughout New Zealand, cost and production information is becoming more available and reliable. The costs for establishing a fodder beet cost in New Zealand has been based on industry figures and fodder beet specialists. The figure used in this model was $2,200/ha, including seed, direct drilling, fertiliser, herbicide and pesticide costs. This figure was supplied by Jim Gibbs (2016), who is a well-recognised fodder beet specialist, calculated from the average per hectare costs of several large, experienced, agronomy providers who annually oversaw greater than 5000 hectares of beet grown, each. The higher end figure was used to provide a buffer for the results, and ensure there was no costs cut to unfairly advantage one system over the other. The conservative anticipated yield of 22t/ha is being used for the cost of fodder beet.

3.4.2 Animal Intakes

Most animals can only consume 3% of their body weight (kg) per day. Animals achieving 3% are often pregnant, lactating or in a fast growth period. Animals grazing fodder beet in this system will change from 150kg to 405kg (Table 2.2), meaning their demand will increase with time. There are two scenarios on fodder beet presented, one achieving maximum live weight (*Ad-Libitum* feeding) and one meeting the DairyNZ target weights (Restricted Feeding).

Ad Libitum

On the *Ad-libitum* diet animal intakes were 2.5% of live weight on grass and 2.2% on fodder beet. These are considered maximum intakes, using data drawn from Gibbs and Saldias (2014), the only published work on young stock beet intakes available. The daily average intake of fodder beet in this period was 5.05kg, which was supplemented with 1kg of grass. The daily average intake of grass was 5.8kg.

Restricted

On the restricted diet animal intakes vary from 2.5% to 1.7%. These restrictions have been enforced to ensure animals do not exceed the DairyNZ targets. The average daily intake of fodder beet was 3.6kg, which was supplemented with 1kg of grass. The average daily intake of grass was 4.5kg.

There will be a lot of variability in intakes over the 22 months due to a transitional period and higher intakes as the heifers reach maturity, the average accounts for these so that one flat value can be used in calculations. Although calves will be consuming 900kg of fodder beet over the rearing period, 1000kg/calf has been used in the budget. This is allowing for utilisation rates of 90%, which is used as standard in in fodder beet grazing systems, as the direct utilisation experimental work in Canterbury has demonstrated (Gibbs and Saldias 2015; Saldias and Gibbs 2016). The same process was applied to the grass-grazing period, with an utilisation of 75%.

3.4.3 Labour Costs

As labour cost is becoming a growing issue in the New Zealand agricultural sector, it was very important to ensure this figure was accurate and above minimum wage. All New Zealand employees are entitled to 4 weeks annual leave (or repayment at 8% of total before-tax earnings) as well as 11 statutory days (public holidays and anniversary days). Most dairy farm employees are paid on a salary based system, this means they are often paid for a standard working week without over time, sometimes not meeting minimum wage requirements of $15.25 (EmploymentNZ, 2003). To ensure this model was as accurate as possible, a figure of $25 is being assumed as labour costs, which protects employees with an annual salary of over $44,000 (Table A.3). The labour values are included to quantify the increased worked load and time of managing the herd on platform. This accounts for the shifting of electric fencing, which is an essential area of grazing to ensure there are no animal health implications. The labour requirement for this model has been based on 0.5 hours for 150 days at $25/hour. It is important to identify that this is a fixed cost, which is spread over the entire herd. The Canterbury average herd size of 806 cows (DairyNZ, 2014) has been used, with a replacement rate of 20% per season. This brings the national average heifer herd size to 161 cows (Table A.4), which the labour costs have been spread across to ensure reliable results. However, this figure will decrease or increase depending on herd size.

3.4.4 Animal Health

Vaccines, drench and trace elements

The animal health costs for both contract grazing and fodder beet on platform are the same. These have been set at $54.09/cow (Gibbon, 2016) (Table A.5); this includes vaccines, drenches and minerals/trace elements. There is an argument that the fodder beet will have slightly lower animal health costs, as the risk of parasites is lower, however there was no research available to support this.

Breeding

Breeding costs have been included at $50/head (DairyNZ, 2011a), which include the cost of AI semen and cost of the insemination from registered professional.

Deaths

As deaths within the herd when grazing fodder beet are a fixed cost, they have been spread across the herd to ensure accuracy. Deaths from fodder beet in this model have been set at 1%, however it is likely that these could be lower, such as 0.05% (Gibbs, 2016). This still requires further research to be confirmed so has been excluded. The value of heifers were set at $1,100 (Interest, 2016), which is the current price from My Livestock auctions. From here the Canterbury average heifer herd size of 161 was used to calculate the number of deaths. The cost of these deaths were spread across the 161 heifers to obtain a per cow cost (Table A.6).

3.4.5 Effluent and Fertiliser Costs

Although the cost of establishing a fodder beet crop ($2,200/ha) has been used there is an opportunity to lower the cost of crops through using effluent. If effluent is able to cover the cropping area, it is possible to reduce fertiliser costs by up to $500/ha (Gibbs, 2016) (Table A.7), depending on the soil and crop requirements. However, this value has not been added into the calculation as it is not applicable to all farmers and the aim of this model is to be reliable and accurate for the majority of farmers. Effluent is a very important and useful tool for farmers. The effluent from 650 cows, which is below the average Canterbury herd size, can fertilise 35ha with 200kg N/ha and 200 kg K^+/ha.

3.4.6 Opportunity Cost

The opportunity cost of a crop expresses a monetary value of the area used for the crop during non-productive periods. For example the period before the fodder beet is established and the period after the fodder beet has been grazed. The opportunity cost is worked out by the value of the pasture ($/ha), which could have been produced. The opportunity cost for a fodder beet crop is $1,600/ha based on calculations found in Table A.8 and A.9 these were based on a pasture producing 15,000kgDM/ha annually. However, this will vary greatly dependent on region and pasture quality. A range of opportunity costs are shown in Table A.10.

3.5 Contract Grazing

3.5.1 Live weight Gain

Live weight gains for contract grazing have been set as a fixed weight to account for the larger variety between graziers throughout New Zealand. For this situation the target weight has been set from DairyNZ (2015a) targets, with heifers achieving 405kg at 22 months.

3.5.2 Grazing Prices and Contracts

Grazing contracts have been set with three price brackets

1. December to 1st May - Calf

2. 1st May to 1st May – Rising 1 year olds

3. 1st May to 22 months – Rising 2 year olds

This is a common practice throughout New Zealand and May 1st is used in the majority of contracts (McGillivary, 2016). The price ($/head/week) changes a lot due to the season and milk price. For weaners the minimum and current price has been set at $5.50 and an upper limit price of $8. Heifers have a lower and current price of $10.50 with and upper limit of $13. Cows from their second May have a minimum of $23 and an upper limit of $32.

Table 3.1 Grazing scenario prices ($/head/week)

	Historic Prices	Current Prices
Weaner	$8.00	$5.50
Heifer	$13.00	$10.50
Cow	$32.00	$23.00

3.5.3 Deaths

Deaths have been included at a rate of 0.5% over the rearing period. This is a very low figure as deaths are unlikely, but are included to account for an adverse event or illness.

3.5.4 Transport Costs

Transport costs have been estimated at $9/head for a 135kg heifer travelling 50km to the grazier and $15/head for 400kg heifer returning the 50km to the milking platform. These prices have been sourced directly from Ellesmere Transport, Canterbury.

3.6 Buying Grass

3.6.1 Live weight gains

Live weight gains within this scenario have been set to mimic the DairyNZ (2015a) target weights. This is done through pasture intakes of 2.2% across the entire 22 months.

3.6.2 Pasture ME

Pasture ME values were set at different rates throughout the seasons to match pasture quality across New Zealand. The values were 10, 11, 11 and 11.5 MJME/kgDM for summer, autumn, winter and spring respectively. These values were sourced from previous literature and industry professionals (Webby & Bywater, 2007) (Gibbs, 2016).

3.6.3 Utilisation

Pasture utilisation was set at 70% during summer, autumn and spring. Utilisation rates were lower during the winter period at 60%.

3.6.4 Grass price

The grass price is set at 20c/kgDM, which was based on current and historical prices within New Zealand. As the price will have a large influence on the cost of grazing in a pasture only scenario, the costs will be compared at various grass prices. A method for grass calculations can be found in Table A.11 that is based on a 70% utilisation rate and 15,000kgDM/ha annual production. This method compares pasture consumed against total costs to produce the pasture (Hughes, 1997).

Chapter 4

Results

4.1 Fodder Beet Grazing

4.1.1 Live weight gains on fodder beet

The two scenarios of fodder beet grazing have been compared to show fodder beets potential to sustain high levels of live weight gains. In the restricted scenario heifer intakes varied from 1.8% on fodder beet pre-calving to 2.5% as young stock on grass (Table A.1, A.2). The live weights achieved over 22 months were similar to DairyNZ targets, finishing at 410kg, gaining a total of 320kg. Daily live weight gains on fodder beet ranged from 0.31-0.85 kg LWT/day (Table 4.1). Heifer intakes on the *Ad Libitum* diet ranged from 2.2% on fodder beet to 2.5% on pasture. The weights achieved were theoretical and above target, with heifers finishing at 524kg, gaining a total of 434kg (table 4.1). Daily live weights ranged from 0.27-1.62 kg LWT/day when grazing fodder beet.

Table 4.1 Comparison of live weight gain on a restricted and Ad Libitum fodder beet diet. Heifers grazing fodder beet from 9 – 14 and 20 – 22 months.

		Restricted Fodder beet diet		Ad Libitum Fodder beet diet		
Month	**Age (Months)**	**LWT gain/Day**	**LWT (Kg at end of month)**	**LWT gain/Day**	**LWT (Kg at end of month)**	**Target Live weights from DairyNZ**
December	5	0.34	100	0.28	99	
January	6	0.31	110	0.31	108	**135**
February	7	0.34	120	0.34	118	
March	8	0.45	134	0.44	131	
April	9	0.40	146	0.43	144	**180**
May	10	0.44	159	0.48	159	
June	11	0.48	174	0.53	175	
July	12	0.53	190	0.58	193	
August	13	0.58	208	0.65	213	
September	14	0.65	227	0.73	235	
October	15	0.73	250	0.95	265	**270**
November	16	0.80	274	1.07	297	
December	17	0.65	294	0.93	326	
January	18	0.70	316	1.02	357	
February	19	0.75	337	1.12	388	
March	20	0.74	360	1.32	429	
April	21	0.79	384	1.47	473	
May	22	0.85	410	1.62	524	**405**

4.1.2 Cost of Gain

The fodder beet scenarios vary greatly in cost due to feed consumed. The *ad libitum* diet required 24ha of grass and 10ha of fodder beet for 161 heifers (average herd size) (Table A.1). The restricted required 19ha of fodder beet and 7.2ha of grass for 161 cows (Table A.2). The restricted fodder beet diet had a cost of $724.66/head for the rearing period, considerably lower than the *ad libitum* diet of $866.46/head (Table 4.2).

Table 4.2 Simplified fodder beet budget for *ad libitum* and restricted diets

	Restricted	**Ad Libitum**
Crop Costs		
c/kgDM	10	10
Fodder Beet Consumed	$107.65	$142.02
Pasture Consumed	$380.03	$453.64
Animal Health		
Total	$54.09	$54.09
Animal Breeding		
Total breeding costs	$50.00	$50.00
Deaths		
Total Cost/head	$11.00	$11.00
Labour		
Total/head	$23.29	$23.29
Opportunity Cost		
Total/head	$98.61	$132.42
Total/head	**$724.66**	**$866.46**

These costs are inclusive of all animal costs and are based on a grass price of 20c/kgDM. Fodder beet price is set at 10c/kgDM based on $2,200/ha to establish and a yield of 22t/ha. As live weights vary between the diets (table 4.1) the cost of live weight gain ($/kgLWT) is also different. The cost of gain for the restricted diet was $2.27/kgLWT, more expensive than $2.00/kgLWT on an ad-lib diet.

Table 4.3 Cost of live weight gain on ad libitum and restricted fodder beet diets

Live weight gain	Restricted	Ad Libitum
	kg	Kg
5 months	90	90
22 months	410	524
Live weight gain	320	434
$/Kg LWT gain	**$2.27**	**$2.00**

The cost of fodder beet consumed has a large influence on the total cost of grazing. The cost of fodder beet consumed (Table 4.4) and the total cost of grazing (Table 4.5) has been compared at different feeding levels and crop costs to show the effect on prices. The cost of fodder beet on the restricted scenario increases from $86 to $129 as the cost of the crop increases from 8 to 12c/kgDM. However, when feeding level increases from the restricted to *ad libitum* (1420kg) feeding level the cost of fodder beet increases from $108 to $142 at 10c/kgDM. Similar trends are seen on Table 4.5, which is inclusive of all grazing costs and reflects the total cost per head ($/head).

Table 4.4 Sensitivity analysis showing the effect of fodder beet intake and crop cost on total cost of fodder beet ($/head).

		Cost of fodderbeet crop (c/kgDM)				
		8.0	**9.0**	**10.0**	**11.0**	**12.0**
Total FB required (kg/cow)	**1076**	$86	$97	$108	$118	$129
	1100	$88	$99	$110	$121	$132
	1200	$96	$108	$120	$132	$144
	1300	$104	$117	$130	$143	$156
	1420	$114	$128	$142	$156	$170

Table 4.5 Sensitivity analysis showing the effect of fodder beet intake and crop cost on the total cost of grazing ($/head).

		Cost of fodder beet crop (c/kgDM)				
		8.0	**9.0**	**10.0**	**11.0**	**12.0**
Total FB required (kg/cow)	**1076**	$703	$714	$725	$735	$746
	1100	$705	$716	$727	$738	$749
	1200	$713	$725	$737	$749	$761
	1300	$721	$734	$747	$760	$773
	1420	$731	$745	$759	$773	$787

The cost of gain ($kg/LWT) is influenced by the crop cost and the total live weight gain (kg/cow) over the rearing period. The cost of gain for a heifer achieving 300kg increases from $2.28 to $2.40/kgLWT as the crop price increases from 8 to 12c/kgDM (Table 4.6). As the live weight gain of a heifer increases from 300 to 500kg over the 22 months the cost of gain decreases from $2.34 to $1.40/kgLWT based on a crop cost of 10c/kgDM (Table 4.6).

Table 4.6 Sensitivity analysis showing the effect of fodder beet crop cost and total live weight gain on the cost of live weight gain ($/kgLWT)

		Cost of fodder beet crop (c/kgDM)				
		8.0	**9.0**	**10.0**	**11.0**	**12.0**
Total live weight gain (kg/cow) over 22 months	**300**	$2.28	$2.31	$2.34	$2.37	$2.40
	350	$1.96	$1.98	$2.01	$2.03	$2.05
	400	$1.71	$1.73	$1.76	$1.78	$1.80
	450	$1.52	$1.54	$1.56	$1.58	$1.60
	500	$1.37	$1.39	$1.40	$1.42	$1.44

4.2 Contract Grazing

The cost of contract grazing was expressed as two figures, current and historic, this is to account for the down turn of the dairy industry. The historical price is $1,121/head and $897/head (Table 4.7) based on the prices shown in Table 3.1.

Table 4.7 Comparison between the total cost ($/head) of contract grazing at current and historic prices for 22 months

Grazing Cost	Historical Prices	Current Prices
	$/Head	**$/Head**
Contract Price		
Total	$987.57	$762.57
Animal Health		
Drench	$19.48	$19.48
Vaccinations	$26.52	$26.52
Trace elements	$8.09	$8.09
Total	$54.09	$54.09
Animal Breeding		
Total breeding costs	$50.00	$50.00
Deaths		
Total Cost/Cow	$5.50	$6.00
Transport Costs		
180kg Heifer	$9.00	$9.00
350kg Heifer	$15.00	$15.00
Total Cost	$1,121.16	$896.66

Contract grazing is based on meeting target live weights, set either by the farmer together with grazier, LIC or DairyNZ. The live weight targets have been kept the same across historic and current prices. Grazing at historic prices results in cost of gain being $3.65/kg of live weight, much higher than the $2.85/kg of live weight at current prices (Table 4.8).

Table 4.8 Comparison between the cost of live weight gain ($/Kg LWT) for contract grazing at current and historic prices for 22 months

	Historical Prices	Current Prices
	Kg	**Kg**
5 month target weight	90	90
22 month target weight	405	405
Live weight gain	315	315
$/kg live weight gain	**$3.56**	**$2.85**

Table 4.9 Sensitivity analysis showing the cost of feed (contract price) ($/head/heifer) at various grazing rates.

		Cost of grazing ($/head/week) as a weaner for 5 months					
		$5.50	**$6.00**	**$6.50**	**$7.00**	**$7.50**	**$8.00**
Cost of grazing ($/head/week) as a heifer	**$10.50**	$666	$677	$688	$699	$709	$720
	$11.00	$692	$703	$714	$725	$735	$746
	$11.50	$718	$729	$740	$751	$761	$772
	$12.00	$744	$755	$766	$777	$788	$798
	$12.50	$770	$781	$792	$803	$814	$824
	$13.00	$797	$807	$818	$829	$840	$850

Grazing prices are variable for contract grazing, however weaner and heifer costs will move with each other. At the current and low price the cost of the grazing contract for 22 months is $666/head, lower than the historic and upper end price of $850/head (table 4.9). This price includes the cost of feed only.

Live weight gain on grazing contracts has remained the same due to graziers aiming to meet industry standard targets (405kg at 22 months). As the grazing contract prices increase the cost of live weight will also increase. At the current and low the cost of live weight gain is $2.54/kg LWT, which increases to $3.81/kg LWT when contract prices are high (table 4.10). This is inclusive of all costs to rear a heifer to 22 months.

Table 4.10 Sensitivity analysis showing the effect grazing contract costs has on the cost of live weight gain ($/kg LWT) over 22 months

Total $/Head grazing (22 months)	$/Kg LWT gain
$896.66	$2.85
$900.00	$2.86
$1,000.00	$3.17
$1,100.00	$3.49
$1,121.16	$3.56

4.3 Buying Grass

4.3.1 Live weight Gain

The third scenario of rearing heifers on brought grass has a total live weight gain of 316.3kg with heifers finishing at 412.9kg, slightly above DairyNZ target of 405kg for 22 months. Daily live weight gains ranged from 0.21-1.15 kg LWT/day as the animals grew in age (Table 4.11). Live weights were calculated off daily intakes of 2.2% of the heifer's body weight.

Table 4.11 Live weight gain for heifers reared to 22 months on grass. Calculated with intakes of 2.2%.

Month	Age (months)	Grass Eaten (kg/day)	LWT gain/Day (kg/day)	Weight at end of month (Kg)
December	5	2.0	0.21	96.6
January	6	2.1	0.24	104.1
February	7	2.3	0.26	111.4
March	8	2.5	0.34	121.9
April	9	2.7	0.37	133.1
May	10	2.9	0.41	145.7
June	11	3.2	0.44	159.0
July	12	3.5	0.48	174.0
August	13	3.8	0.53	190.5
September	14	4.2	0.63	209.5
October	15	4.6	0.70	231.1
November	16	5.1	0.77	254.1
December	17	5.6	0.64	273.8
January	18	6.0	0.68	295.1
February	19	6.5	0.74	315.7
March	20	6.9	0.96	345.6
April	21	7.6	1.05	377.2
May	22	8.3	1.15	412.9

4.3.2 Cost of gain

The cost of rearing heifers on platform, feeding a pasture only diet, for this scenario is $830.74/head, based on a grass price of 20c. This is inclusive of animal health, breeding and death costs (Table

4.12). The cost of deaths for this is lower than those on fodder beet due to less complicated management. The cost of live weight gain is $2.57/kg LWT gain in this grazing scenario (Table 4.13).

Table 4.12 Budget for heifer rearing by buying grass for 22 months

Cost of Grazing grass for 22 months on platform			
Grazing Costs	**$**	**$/Head**	**$/Head**
Grass Price		$720.65	
Total			$720.65
Animal Health			
Total			54.09
Animal Breeding			
Total breeding costs			50
Deaths			
Cost of Heifer	$1,100		
Total Cost of Deaths		$885.50	
Total Cost/Cow			$6
Total Cost			**$830.74**

Table 4.13 Cost of live weight gain ($/kg LWT) over 22 months

Live weight gain	LWT (kg)	LWT (kg)	Cost of Gain ($/kg LWT)
5 months target Weight	90.0		
22 months Target Weight	412.9		
Total live weight gain		322.85	
$/Kg LWT gain			**$2.57**

As the cost of grass (to buy as silage or grow) increases the total cost of grass required will also increase, at a lower limit of 16c/kgDM the total grass cost is $576.24 (Table 4.14) and $2.13/kg LWT (Table 4.15). At the higher grass price of 20c/kgDM the total grass cost was $937 (Table 4.14) and $3.02/kg LWT (Table 4.15)

Table 4.14 Sensitivity analysis showing the effect of grass price (c/kgDM) on the total cost of grass required ($/head) over 22 months

Grass price (c/kgDM)	Cost of grass ($/head)
16	$576.52
18	$648.59
20	$720.65
22	$792.72
24	$864.78

Table 4.15 Sensitivity analysis showing the effect of grass price (c/kgDM) on the cost of live weight gain ($/head)

Grass price (c/kgDM)	Cost of Gain ($/kg LWT)
16	$2.13
18	$2.35
20	$2.57
22	$2.80
24	$3.02

4.4 Comparison

All of the grazing systems above, except *ad libitum* fodder beet, have been compared in different forms (Table 4.16). *Ad libitum* fodder beet has been excluded due to the large difference in live weight gain, which may not be practical for New Zealand dairy farms. Contract grazing was the most expensive at $10.19 and $12.74/head/week for the current and historic prices respectively. On-platform pasture rearing was the third most expensive at $9.55/head/week. Restricted fodder beet was the cheapest rearing system at $8.23/head/week.

Table 4.16 Comparison of grazing costs on systems meeting DairyNZ target weights

	Fodder Beet (restricted)	Contract Grazing (Current Prices)	Contract Grazing (Historical Prices)	On-platform Pasture
Total over 22 months ($/head)	$724.66	$896.66	$1,121.16	$830.74
Cost of gain ($/kgLWT)	$2.27	$2.85	$3.56	$2.57
Cost per week ($/head)	$8.23	$10.19	$12.74	$9.44

Due to these systems not meeting target live weights for mating (15 months) as well as pre-calving (22 months), hybrids have been compared to increase the practicality and make the scenarios as close to real life practice as possible. These include *ad-libitum* feeding to make the mating requirements, followed by a restriction to ensure heifers are close to target weights pre-calving. The cost of gain on a hybrid feeding system was $2.31/kgLWT for fodder beet and $2.66/kgLWT for pasture grazing (Table 4.17). Animal intakes and live weight gain can be found in Table A.12 for pasture grazing and Table A.13 for fodder beet.

Table 4.17 Comparison of practical grazing systems meeting target live weights at both mating and calving.

	Fodder Beet (hybrid)	**On-platform pasture (post mating restriction)**
Total over 22 months ($/head)	$769.86	$870.06
Cost of gain ($/kgLWT)	$2.37	$2.66
Cost per week ($/head)	$8.75	$9.84

Chapter 5

Discussion

5.1 Live weight gain

Rearing heifers to achieve target live weights in a crucial part of dairy farm systems. Heifer rearing has been identified as a limiting factor in increasing the reproductive performance of the New Zealand dairy herd. Ensuring heifers have reached target live weights for mating (13-15 months) is important to ensure they have gone through puberty and are in the best possible position to get in calf. In New Zealand 61% of heifers are underweight by 11-20% at 15 months of age (McNaughton & Lopdell, 2012). Mating weights in this study were also below weight at mating. The *ad libitum* fodder beet diet showed the smallest difference at 1.8% (5kg), which was greater than both restricted fodder beet and grass diets. The restricted fodder beet diet was the second performing diet at 7.4% (20kg) below target. The pasture diets were 14.4% below target at 15 months, within the 11-20% range from published data due to this currently being the most common grazing system in New Zealand (McNaughton & Lopdell, 2012). However, further assessment of the feeding levels showed that a combination of restricted and *ad libitum* feeding had the potential to reach target live weights at mating on both fodder beet and pasture. The live weights at 15 months were 274kg and 273kg respectively. A study by Short and Bellows (1971) showed that feeding level had a significant effect on pregnancy level, with low feeding levels having pregnancy rates of 50% compared to 86% and 87% in medium and high feeding levels respectively. Previous research from Ireland has shown that body weight and BCS at mating start date (MSD) are significantly affected by pubertal rate ($P<0.05$) (Archbold et al., 2012). Body weight was favourably associated with calving date and milk lactation. Larger heifers at mating showed they were more profitable over three lactations (table) due to higher lactation production potential. Heifers at lower BW at MSD calved later, produced less milk and produced lower farm profit over the three lactations (Table 2.3). This supported by published data that suggest a 1kg increase in immature live weight will result in a lactation yield increase of 6.7 litres in the first season, however, responses may be lower in subsequent seasons (Vander Waaij et al., 1997). However, due to poorer reproductive production in those grown above 343kg at MSD, heifers at 330kg as MSD was deemed to be optimum. This supports the DairyNZ target weights and importance of meeting them, as the optimum weight in this study was 60% of a mature Holstein-Friesian live weight.

The New Zealand dairy industry aims to achieve a 78% in-calf rate after 6 weeks of mating. The current average in New Zealand is 65%, which heifer rearing holds some responsibility for (LIC, 2012). This figure is important as increasing the amount of cows in-calf during the first 6 weeks will shorten the calving period, increase the days in early lactation, increase amount of AI calves and result in less empty cows. Because New Zealand dairy industry is an outdoor and extensive farming system, it is different to overseas systems, as cows are expected to calve within the next 12 months to maintain a compact calving period. This is to match the seasonal pasture supply, as well as weather conditions. To increase the six-week in-calf rate cows must be cycling at the beginning of mating, this is directly related to live weight, emphasising the importance of heifer rearing. A study by Byerley *et al.* (1987) showed that heifers that had undergone their third oestrous has a 78% conception rate, compared with 57% in heifers on their first oestrous cycle. Important future research would be to follow different heifer rearing systems through to mating, calving and the lactation season. This would help farmers make an informed choice about rearing systems.

Mating in New Zealand is traditionally a 12-week period, with the first 9 weeks being AI. The end of calving and final measure is an empty rate. The average empty rate for New Zealand in 2011 was 13% with the top 25% of farms achieving 10%. This is based on the entire herd, not young stock only. VetCare grazing has a 6-7% empty rate when heifers are returned to farm after 22 months of grazing (McGillivary, 2016). This is meeting the industry target on traditional pasture grazing. Over the last 2 years VetCare have been blood testing in July (12 months) and August (14 months) to monitor selenium levels. The results of this test determine supplementation levels, without requiring farmer input. This is a large benefit for those who want less responsibility over their heifers, while being ensured they are in the hands of fully trained and capable veterinarians. Selenium levels can cause retained foetal membranes, this can lead to reduced or delayed fertility in cows, supplementing this along with Vitamin E can reduce these chances (Harrison, Hancock, & Conrad, 1984).

Live weight surrounding the calving period (24 months) is also a significant factor in management and performance of dairy farms. The target live weight at 22 months is 90% of mature weight, for an HFxJ this is 405kg. The *ad libitum* fodder beet diet produced the largest heifers, which were 29.4% above target weight (405kg). This was larger than the live weights on all other diets. There was very small difference between the restricted fodder beet and pasture diets, 1.2% (410kg) and 1.9% (413kg) above the target weight. The diets compared later in the study showed that implementing a restricting after mating can still result in pre-calving target live weights being meet. The hybrid fodder beet and pasture grazing diets resulted in pre-calving live weights of 415kg and 417kg respectively, either at or above target live weights. Over weight or over conditioned (BCS>5.5) cows at calving are at risk for metabolic diseases which will have lasting effects on the lactation season. The two main metabolic diseases in New Zealand dairy farming systems are milk fever and ketosis. Milk fever is a metabolic disorder caused by insufficient calcium (Ca) levels in the blood. Ketosis is related to the cow mobilising large quantities of body fat to meet the energy demands of milk production. Cows cannot use traditional pathways to meet energy demands therefore ketone bodies are produced. When ketone body production is high and the cow cannot utilise the energy, ketone levels in blood increase, resulting in ketosis. Cows that have been over feed in the pre-calving period, or are over-fat (BCS greater than 5.5) at calving are high risk for ketosis as they have excess fat reserves to mobilise. Heifers on *ad libitum* fodder beet diet could be at risk as they are 29.4% over target. The hybrid systems have little risk of being over fat, as they are both around 10kg over target, which is less than half a BCS, which is recognised as 40kg.

Although pasture grazing, either contract or on platform, is capable of meeting live weight targets at 22 months it is less consistent than fodder beet. It is seasonally dependent and is unlikely to meet live weight targets at mating. The winter period has a large influence on grazing decisions, although pasture quality is high, pasture growth rates are low. Which can result in feed deficits, or lower quality supplementations, which were not represented in this investigation. It was assumed that the stocking rate meet the pasture supply, the pasture diet required 14ha for 161 cows however this would be different in a real life situation due to pasture rotations and grazing pressure. During the crucial winter period, leading up the mating (11-13 months), the weight gains on the *ad libitum* fodder beet diet and restricted fodder beet diet were 0.59 kgLWT/day and 0.53 kgLWT/day respectively, higher than 0.49 kgLWT/day seen in the pasture grazing systems. Having the ability to feed a forage crop, particularly fodder beet due to constant yields and energy levels, takes the pressure of managers, as there is a lower chance of not achieving desired live weight gains. Increasing this consistency has many benefits for farmers or managers, both financial and personal.

The different grazing scenarios have benefits and disadvantages throughout the rearing period. The *ad libitum* fodder beet diet was most beneficial during the early stage of rearing through till mating, achieving an average live weight gains of 0.52kgLWT/day, placing the animals only 1.8% (5kg) below target at mating. With the restricted fodder beet and pasture diets achieving 0.48kgLWT/day and 0.42kgLWT/day. This shows that the best diet to ensure success at mating is the *ad libitum* fodder beet diet. After mating the live weight gains seen on the *ad libitum* diet has an average of 1.22kgLWT/day, higher than 0.75kgLWT/day and 0.86kgLWT/day seen on the restricted fodder beet and pasture diets respectively. The *ad libitum* fodder beet live weight gains resulted in over-weight heifers at calving, which is not a desired attribute in the dairy industry. The best heifer rearing system based on live weight gain would be an *ad libitum* diet until mating, followed by a carefully managed and restricted diet on either fodder beet or pasture leading up to calving. This pre calving restriction is supported by recent results which found pre-calving feeding levels did not affect overall milk yields, although milk fat % was increased ($P<0.05$) as pre-calving feeding was increased, but was not evident 5 weeks post calving (Roche, 2007).

5.2 Cost of Gain

5.2.1 Fodder beet

Rearing heifers on fodder beet proved to be very successful in gaining live weight. Results showed that is also the cheapest rearing scenario (Table 4.16), with restricted fodder beet grazing only costing \$2.27/kgLWT gain and \$724.66/head for the 22-month period. On the *ad libitum* diet the cost of gain decreased to \$2.00kg/LWT gain regardless of the total price increasing to \$866.46/head. This shows that live weight gain is a key driving force for the cost of heifer rearing. However, this situation was achieving far higher, and undesirable, live weights than the other scenarios, so it is an unfair representation of fodder beet rearing costs in the New Zealand dairy industry.

The cost of fodder beer crops were set at 10c/kgDM based of establishment costs of \$2,200/ha and 22t/ha yields. However, it is widely recognised by industry professionals that using on farm effluent can reduce crop costs by \$500/ha (Gibbs, 2016). This is because the nutrients within the effluent decrease fertiliser requirements for the crop (Table A.9). Effluent spreading is an important process for many New Zealand farmers to create value. There are rules and regulations regarding on-farm spreading surrounding the area and rate of application. Because of this it is not guaranteed that cropping areas will be covered by effluent, however there are large financial benefits if covered. Reducing the establishment costs to \$1,700/ha with the same yield reduced the cost of fodder beet to 8c/kgDM. The sensitivity analysis' shown in Table 4.4 and 4.5 indicate that reducing crop costs to 8c/kgDM on the restricted diet will reduced fodder beet costs to \$86 and total grazing costs to \$703/head, increasing the gap between the fodder beet costs and other scenarios.

The cost of gain on the restricted fodder beet was the least expensive of all the grazing scenarios at \$2.27/kgLWT, however the most practical scenario was the hybrid fodder beet system at \$2.37/kgLWT. This is influenced by two factors, live weight gain and cost of fodder beet. As the fodder beet crop cost decreases, the cost of gain will also decrease. When live weight gain over the period increases, the cost of gain decreases. However, when live weight increases by 50% at any given fodder beet crop cost the cost of gain will decrease by 49% (Table 4.6), which was equivalent to \$0.79/kgLWT at the crop cost of 8c/kgDM. The effect of crop costs on the cost of gain was much smaller. A 50% price decrease from 12 to 8c/kgDM decreased the cost of gain by 5%, which was \$0.12/kgLWT at a 300kg total live weight gain (table 4.6). This shows that live weight gain, not cost of crop, is the main primary driver of cost of gain. Optimising live weight gain, within target live weight boundaries (BCS between 4.5 and 5.5) is the best way to decrease cost of gain in a fodder beet rearing system.

5.2.2 Contract

The cost of contract grazing can change a lot between seasons. Although the price of grazing changes with each season, often due to the dairy payout, the quality of the grazing should be maintained across seasons. Guaranteeing live weight targets are reached is a positive quality which draws farmers to contract grazing as a heifer rearing option. As the majority of grazing demand comes from within the dairy industry, when dairy prices are low farmers will cut cost where possible which will include sending heifers off platform. VetCare grazing (Whanganui) has seen a drop in heifer numbers from 9,000 to 7,000 in the previous season when the Fonterra payout dropped to $3.95 (without dividend). This is also seen in opposite when the dairy industry is making large operating profits; more farmers look for off platform grazing, which drives prices up.

The New Zealand industry is currently in a down turn due to the global dairy auction price decrease. This has seen grazing prices drop as low as $896.66/head, based on a weaner price of $5.50/head/week, heifer price of $10.50/head/week and a cow price of $23/head/week. When based off the DairyNZ target weights, the heifers would achieve 315kg over the 22 months, at a cost of gain of $2.85/kgLWT. At this price contract grazing is the most expensive form of rearing, however it does have non-financial benefits. As the dairy price increases, it is common for the grazing price to also increase. Table 4.9 shows the variability between the lower and upper limit of grazing prices and the effect that this has on the cost of grazing (exclusive of other costs). These prices always move together as they are linked to the amount of feed consumed. The historic prices are more expensive with weaners at $8.00/head/week, heifers at $13.00/head/week and cows at $32.00/head/week. This results in a cost of gain of $3.56/kgLWT, much more expensive than other rearing systems. There can also be other costs involved depending on the contract or company, which the grazing is done through. Many companies have an incentive system in place, where farmers are also paid on live weight. VetCare Whanganui pays $1.67/kg (McGillivary, 2016). Although more expensive, there are benefits of contract grazing such as guaranteed live weights that will make it appealing to farmers.

5.2.3 Buying Grass

Pasture grazing on platform or run-off is the second cheapest option at $2.57, behind only fodder beet. The hybrid pasture grazing system, which meet target live weights at all times, had a cost of gain of $2.66/kgLWT. The price of this system is very vulnerable to change. The price of grass changes quickly due to growth rates being dependent on weather and soil type. In a good growing season with little fertiliser inputs, the grass price could drop to 16c/kgDM, resulting in a cost of gain of $2.13/kgLWT, lower than fodder beets cost of gain. However, the opposite effect is seen when grass is grown or purchased at a cost of 24c/kgDM. Cost of gain increases to $3.02/kgDM, which would be the second most expensive rearing system behind contract grazing at historic prices. This system required 24ha of pasture, however this would be higher due to grazing rotations and growth rates. When grazing heifers on-platform or run-off block it is important to consider whether this system is convenient for the farmer, the distance to the run-off block and land interest prices. These were not included in the price due to lack of information available and is an area that requires future research.

The benefits of well-reared heifers are invaluable to a dairy farm. The increase productivity, fertility and improved genetics due to AI mating will have long and lasting effects on any dairy farm. Due to inconsistences in heifer rearing, more heifers are reared than required for replacements. Being able to ensure heifers will be reared successfully gives farmers two options; to rear less heifers as all will between the requirements to be herd replacements, or to continue the current numbers and pushing live weight gains on surplus heifers and sell on the beef market. Or sell in-calf heifers, the current market are valued at $1,100/head (Interest, 2016). These could serve as either a reduced cost of alternate income source.

5.3 Management

Live weight gain and cost of gain will greatly influence the rearing system chosen by farmers. However the farmer's age, goals and stage in life will also effect the decision made.

Pasture grazing on platform or run-off is the most traditional form of heifer rearing in New Zealand. This is a low management system, which does not require any additional preparation or staff. However, it does require a strong knowledge of pasture management. A lot of older generation farmers who are happy with their farm performance and have been rearing successful on pasture throughout their career are likely to stick to this system, regardless of research supporting fodder beet or contract grazing. Pasture rearing on platform or run-off involves needing adequate area to rear on platform or a convenient run-off block that is close and easily accessible to monitor these young stocks.

Fodder beet is still very new to the farming industry meaning there are still issues involving management and stock health. Fodder beet, along with all high energy feeds, has a risk of rumen acidosis occurring. This is due to the rumen fermenting the high energy levels to volatile fatty acids at an increased rate; this increases the pH within the rumen resulting in suppressed appetite and compromised rumen flora. There are significant differences in risks of acidosis between *ad libitum* and restricted diets (J. Gibbs & B. Saldias, 2014) as the feeding pattern is altered, and restricted diets are far more dangerous to operate. Regardless of feeding level, careful and knowledgeable management of the crop is required. Fodder beet crop fences need to be very accurate and heifers shifted regularly between the crop and pasture or other supplement. Skilled labour units are increasingly hard to find and demands various people management factors, which may put farmers off using fodder beet as a rearing option. Both fodder beet and on-platform pasture grazing give the ability for heifers' health and live weights monitored closely as the farmer has complete control. Another positive attribute if fodder beet grazing is that the majority of costs occur between summer and early autumn when the crop is being established. This is during the lactation season, meaning dairy farms income coming into the cashflow each month. Contract grazing is disadvantaged in this respect as there is little cashflow during the winter periods, which make rearing payments during this time more difficult.

Contract grazing gives farmers' freedom during the 22 months with both on farm grazing rotations and less time requirements. This is particularly valuable during the winter period, which is recognised as the less busy period in dairy farming, not having the responsibility of young stock can make holidays and off farm time more achievable. Contract grazing companies such as VetCare pride their business on providing the best animal health possible to stock, which acts as a draw card for many farmers as vets are on call and able to respond quickly to any issues. This combined with the knowledge the graziers can supply farmers, in terms of live weight gain, there are many benefits of this system and is a reliable way of rearing heifers. Most dairy farms do not have the equipment to weigh heifers regularly on farm, which means contract grazing can give more precise information. This system is popular for large farms as they already require a high level of management and have a comfortable operating profit. Large-scale farms also have the option to increase their on-platform stocking rate while using contract grazing, as young stock is off-platform.

The choice of rearing system is highly dependent on personal factor, however it is strongly influenced by live weight and cost. As farmer's goals for their property change, it is also likely that their rearing methods will. Young farmers that are open to new methods or are chasing higher production levels are more likely to pick up the fodder beet system than those who are happy with their production and have been meeting targets with more traditional systems.

5.4 Conclusions

Fodder beet, contract grazing and on-platform pasture grazing all have the ability to achieve target live weights for HFxJ heifers over 22 months. However, fodder beet showed this at restricted animal intakes which indicates it may be the best option to consistently produced well reared heifers at target live weights, provided it is done with good management and information. Fodder beet was also the cheapest option at $2.37/kgLWT for a practical heifer rearing system under current New Zealand prices. From this study, fodder beet could be recommended as a suitable and low-cost option for heifer rearing with high returns.

Fodder Beet

A.1 Animal Intakes

Table A. 1 Animal Intakes on the Ad Libitum fodder beet diet.

Month	Age	Starting LWT	Intake % of BW	Grass consumed (kg)	FB consumed (kg)	ME Available	ME partition	
							Maintenance	Weight Gain
December	5	90.0	2.5%	2.3	0.0	24.8	11.3	13.5
January	6	100.5	2.5%	2.5	0.0	27.6	12.6	15.1
February	7	112.1	2.5%	2.8	0.0	30.8	14.0	16.8
March	8	123.9	2.5%	3.1	0.0	34.1	15.5	18.6
April	9	138.3	2.2%	1.0	2.0	35.5	17.3	18.2
May	10	152.0	2.2%	1.0	2.3	39.1	19.0	20.1
June	11	167.6	2.2%	1.0	2.7	43.2	20.9	22.3
July	12	184.3	2.2%	1.0	3.1	47.7	23.0	24.6
August	13	203.4	2.2%	1.0	3.5	52.7	25.4	27.3
September	14	224.5	2.2%	1.0	3.9	58.3	28.1	30.2
October	15	247.2	2.5%	6.2	0.0	68.0	30.9	37.1
November	16	275.9	2.5%	6.9	0.0	75.9	34.5	41.4
December	17	307.0	2.5%	7.7	0.0	84.4	38.4	46.0
January	18	342.6	2.5%	8.6	0.0	94.2	42.8	51.4
February	19	382.5	2.5%	9.6	0.0	105.2	47.8	57.4
March	20	422.6	2.2%	1.0	8.3	110.6	52.8	57.7
April	21	467.4	2.2%	1.0	9.3	122.4	58.4	64.0
May	22	515.4	2.2%	1.0	10.3	135.1	64.4	70.6

Table A. 2 Animal Intakes on the restricted fodder beet diet.

Month	Age	Starting LWT	Intake % of BW	Grass consumed (kg)	FB consumed (kg)	ME Available	ME partition	
							Maintenance	Weight Gain
December	5	90	2.5%	2.3		24.8	9.0	15.8
January	6	102	2.5%	2.6		28.1	12.8	15.3
February	7	114	2.5%	2.9		31.4	14.3	17.1
March	8	126	2.5%	3.2		34.7	15.8	18.9
April	9	141	2.1%	1.0	2.0	34.5	17.6	16.9
May	10	153	2.1%	1.0	2.2	37.7	19.2	18.5
June	11	168	2.1%	1.0	2.5	41.3	21.0	20.3
July	12	183	2.1%	1.0	2.8	45.1	22.9	22.2
August	13	200	2.1%	1.0	3.2	49.4	25.0	24.4
September	14	219	2.1%	1.0	3.6	54.2	27.4	26.8
October	15	239	2.1%	5.0		55.3	29.9	25.4
November	16	259	2.1%	5.4		59.8	32.4	27.4
December	17	279	2.1%	5.9		64.5	34.9	29.6
January	18	302	2.1%	6.3		69.8	37.8	32.1
February	19	327	2.1%	6.9		75.6	40.9	34.7
March	20	351	1.7%	1.0	5.0	70.7	43.9	26.8
April	21	372	1.7%	1.0	5.3	74.9	46.5	28.4
May	22	394	1.7%	1.0	5.7	79.3	49.2	30.1

A.2 Labour Costs

Table A.3 Labour Costs for casual dairy farm worker

	Labour Cost	
Salary	$44,000.00	
Hours/Week		
46 weeks @ 48h	2208	
Wage/Hour		$19.93

Table A. 4 Average Replacement Herd Size used for labour costs

Canterbury Average Herd Size	806	
Replacement Rate	20%	
Average Heifer Herd Size		161

A.3 Animal Health

Table A. 5 Animal Health Costs (Gibbon, 2016)

Animal Health Costs	Dose	$/animal
Drench		
Arrest C	4 weekly basis until 120kg	$1.49
Eclipse Pour	6 weekly from 120kg till mating	$17.99
Vaccine		
Bovilis BVD	Initial 2 shot and annual booster	$20.64
Ultravac 7 in 1	Initial 2 shot and annual booster	$5.88
Mineral Supplementation		
Copacaps (1x 10g) Copacaps (1x 20g)		$6.65
Prolaject 2000 B12 and Selenium	3 injections	$1.44
		$54.09

Table A. 6 Value of deaths at 0.5% for a heifer in the current market (Interest, 2016)

Deaths	$/Head	Value at death Rate	Total Value/cow
Heifer Value	1100		
0.05% Deaths		55	
Total Value			55

A.4 Fertiliser and Effluent

Table A. 7 Fertiliser Costs for fodder beet crops with and without effluent

Traditional Fertiliser Application			
Fertiliser	Rate (kg/ha)	Note	Cost
DAP	200		
Boron Sulphate	25		
MOP	100		
Ag Salt	100		
Urea	100	2 - 3 dressings of Urea and MOP at same rates	
MOP	100		
TOTAL COST			$700/ha

Fertiliser application with effluent			
Fertiliser	(Rate/kg)	Note	Cost
Boron Sulphate	25		
AgSalt	100		
Urea	100		
TOTAL COST			$200/ha

Note: MOP refers to potassium chloride, which contains potassium 50% and chloride 46%.

Note: DAP refers to Di-Ammonium Phosphate, which contains nitrogen 18% and phosphate 20%

A.5 Opportunity Cost

Table A. 8 Opportunity Cost of the Ad Libitum fodder beet diet

Ad Libitum Fodder Beet Diet			
Fodder Beet establishment			
	kgDM/ha	**$/ha**	**$/total ha**
November	1245	$249	$2,341
December	1245	$249	$2,341
January	1245	$249	$2,341
February	1245	$249	$2,341
Regrassing Costs			
		$702	$6,599
Grass Establishment			
10 Weeks	2850	$570	$5,358
Total Costs			
Total			$21,319
Cost/Heifer			$132.42

Table A. 9 Opportunity Cost of the restricted fodder beet diet

Restricted Fodder Beet Diet			
	Fodder Beet establishment		
	kgDM/ha	**$/ha**	**$/total ha**
November	1245	$249	$1,743
December	1245	$249	$1,743
January	1245	$249	$1,743
February	1245	$249	$1,743
	Regrassing Costs		
			$4,914
	Grass Establishment		
10 Weeks	2850	$570	$3,990
	Total Costs		
Total			$15,876
Cost/Heifer			$98.61

Table A. 10 Sensitivity analysis showing the effect of annual pasture production (kgDM/ha) on opportunity cost of fodder beet ($/ha)

Annual Production (kgDM/ha)	**Opportunity Cost $/ha**
9,000	$1,642
11,000	$1,850
13,000	$2,059
15,000	$2,268
17,000	$2,477
19,000	$2,686

A.6 Grass Price

Table A. 11 Cost of Grass Method

Cost of Pasture (ha)	
Pasture Consumed (kgDM/ha)	11200
Fertiliser Costs	$426
Pasture Renovation and Seed	$273
Hay and Silage	$600
Weed and Pest control	$422
Total ($/ha)	$1,721
c/kgDM	15.4

A.7 Hybrid Systems

Table A. 12 Animal intakes and live weight gains on a hybrid pasture grazing diet.

Month	Age (months)	Intakes as a % of BW	Grass Eaten (kg/day)	LWT gain/Day (kg/day)	Weight at end of month (Kg)
December	5	2.4%	2.2	0.27	98.4
January	6	2.4%	2.4	0.30	107.5
February	7	2.4%	2.6	0.32	116.5
March	8	2.4%	2.8	0.42	129.6
April	9	2.4%	3.1	0.47	143.5
May	10	2.4%	3.4	0.52	159.6
June	11	2.4%	3.8	0.57	176.8
July	12	2.4%	4.2	0.64	196.5
August	13	2.4%	4.7	0.71	218.5
September	14	2.4%	5.2	0.85	244.0
October	15	2.4%	5.9	0.95	273.5
November	16	1.9%	5.2	0.67	293.7
December	17	1.9%	5.6	0.51	309.7
January	18	1.9%	5.9	0.54	326.5
February	19	1.9%	6.2	0.57	342.5
March	20	1.9%	6.5	0.76	366.1
April	21	1.9%	7.0	0.81	390.5
May	22	1.9%	7.4	0.87	417.5

Table A. 13 Animal intakes and live weight gains on a fodder beet grazing system.

Month	Age (Months)	Starting LWT	Intake % of BW	ME Available	LWT gain/Day	End live weight
December	5	90	2.5%	22.5	0.3	99
January	6	99	2.5%	24.7	0.3	108
February	7	108	2.5%	27.1	0.3	118
March	8	118	2.5%	32.4	0.4	131
April	9	131	2.2%	34.3	0.4	145
May	10	145	2.2%	37.9	0.5	160
June	11	160	2.2%	42.1	0.6	177
July	12	177	2.2%	46.5	0.6	196
August	13	196	2.2%	51.6	0.7	217
September	14	217	2.2%	57.8	0.8	240
October	15	240	2.3%	63.4	0.8	266
November	16	266	2.3%	70.3	0.9	293
December	17	293	2.3%	67.5	0.8	317
January	18	317	2.3%	73.0	0.8	343
February	19	343	2.3%	78.9	0.9	368
March	20	368	1.5%	65.3	0.5	383
April	21	383	1.5%	68.0	0.5	398
May	22	398	1.5%	70.7	0.5	415

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